USBPO U.S. BURNING PLASMA ORGANIZATION

eNews

October 15, 2010 (Issue 48)

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Dear Burning Plasma Aficionados:

This newsletter provides a short update on U.S. Burning Plasma Organization activities. E-News is also available online. Comments on articles in the newsletter may be sent to the Editor (Tom Rognlien) or Assistant Editor (Rita Wilkinson).

Thank you for your interest in Burning Plasma research in the U.S.!

Director's Corner by Jim Van Dam

REMINDER: IAEA Fusion Energy Conference and ITPA Meetings

The biennial Fusion Energy Conference, sponsored by the International Atomic Energy Agency, is being held October 11-16, in Daejeon, Korea (http://www.fec2010.kr/). The following week, all seven Topical Groups of the International Tokamak Physics Activity (ITPA) will hold their fall meetings—six in Seoul, Korea, and one in Naka, Japan. In subsequent issues of *eNews*, we will include reports from these meetings.

REMINDER: Burning Plasma Events at the APS-DPP Annual Meeting

The USBPO will sponsor the following events at the APS Division of Plasma Physics Meeting (November 8-12, 2010, Chicago, IL):

- Tuesday (November 9), 7:30-9:30 p.m.: ***Town Meeting on ITER Status*** (Session LE2, Grand Ballroom CD)
- Thursday (November 11), 2:00-4:12 p.m.: ***ITER-I Contributed Oral Session*** (Session UO4, Grand Ballroom A)
- Friday (November 12), 9:30 a.m.-12:30 p.m.: ***ITER-II Contributed Oral Session*** (Session XO4, Grand Ballroom A)

Note: For the ITER Town Meeting on Tuesday evening, in addition to the previously announced speakers—G.S. Lee, Alberto Loarte, and myself—we have also scheduled Brad Nelson, Chief Engineer, US ITER Project, to talk about US engineering, technology R&D, and design activity for ITER. This should make for a very interesting agenda. Be sure to attend the Town Meeting and also the two ITER oral sessions.

30th Anniversary of US-Japan Fusion Collaborations

The meeting of the US-Japan Coordinating Committee on Fusion Energy (CCFE) that will be held during the IAEA Fusion Energy Conference in Daejeon, Korea, will commemorate the third decade of research cooperation between Japan and the US in the field of fusion energy science.

In 1977, President Carter and Prime Minister Fukuda discussed a new US-Japan cooperation on fusion. As a result, a governmental agreement on Japan/US Joint Activity in the field of fusion research and development was established, and the CCFE was started in August 1979. Since then, the Joint Activity has been continued steadily for many years.

In 2000, the CCFE published a 20th Anniversary Report describing the collaborative research activities of the first two decades of the Joint Activity. This year, the CCFE intends to issue a 30th Anniversary Report, covering the past decade and thus bringing the previous report up to date. Two special features of the forthcoming 30th Anniversary Report will be a list of publications that have resulted from the US-Japan Joint Activity and a number of one-page examples of technical research highlights. Stay tuned for more details.

ITPA Coordinating Committee Meeting

For the sake of efficiency, the Coordinating Committee of the International Tokamak Physics Activity (ITPA) decided in July to combine its annual meeting (usually held in the summer) with the annual IEA-ITPA Joint Experiments Planning Meeting (usually held in December) as well as the Executive Committee Meeting for the IEA Implementing Agreement on Co-operation of Tokamak Programs (CTP). This triply combined meeting will be held December 13-15, 2010, at Cadarache, France. The end-of-year date for the combined meeting turns out to be convenient for program leaders to incorporate the ITPA joint experiments in facility operation plans for the following year.

Incidentally, the IEA Implementing Agreement on Co-operation of Tokamak Programs (CTP) was created from the merger of the IEA Large Tokamak Agreement and IEA Polodial Divertor Agreement, which formally (and finally, after five years of discussion) was accomplished a few months ago.

ITER Flag Hoisted at Headquarters

The October 1 issue of *ITER Newsline* reported that the official ITER flag, along with the flags of the seven ITER Members, now flies in front of the ITER Headquarters building. Director-General Osamu Motojima is shown hoisting the ITER flag in the photo. (Note the sizeable gathering of staff members to the far left—and the fact that two flagpoles are not yet being used.)

ITER flag being hoisted by Director-General Motojima.
(Photo from ITER Newsline #148)

USBPO Presentation to National Research Council

On September 25, I gave an invited talk about "ITER Update and Scientific Opportunities" to the Plasma Science Committee of the Board of Physics and Astronomy of the National Research Council, National Academies. The meeting was held at the Beckman Center on the campus of the University of California, Irvine. Most of the discussion following the talk was about how university scientists and students can contribute to ITER and burning plasma research. The talk has been posted on the USBPO web site (Reference page, Other USBPO Presentations section).

USBPO Topical Group Highlights

(Editor's note: This contribution is part of our on-going coverage of research activities relating to different BPO Topical Groups, this month being MHD and Macroscopic Plasma Physics. The group seeks to facilitate U.S. efforts to understand and predict the behavior of large-scale phenomena in existing and future fusion devices (leaders are Ted Strait and François Waelbroeck). This month's research highlight by Richard Fitzpatrick describes an analysis of the plasma response to magnetic error-fields).

Non-Ideal Error-Field Response of a Strongly Shaped Tokamak Plasma

Richard Fitzpatrick (Institute for Fusion Studies, The University of Texas at Austin)

Tokamak plasmas are highly sensitive to externally generated, non-axisymmetric, static magnetic perturbations. Such perturbations, which are conventionally termed *error-fields,* arise primarily from imperfections in magnetic field coils. The resonant harmonics of an error-field (*i.e.,* the helical harmonics which are such that $\boldsymbol{k}\cdot\boldsymbol{B} = 0$ at some rational magnetic flux-surface lying inside the plasma, where $\boldsymbol{k}$ is the helical wave-number, and $\boldsymbol{B}$ the equilibrium magnetic field) are capable of driving locked (*i.e.,* non-rotating) magnetic island chains in an otherwise tearing-stable plasma. Unfortunately, in the presence of such chains, the plasma becomes very disruption prone. Moreover, the critical error-field amplitude required to trigger locked island formation can be as small as 10^{-4} of the equilibrium toroidal field strength [1].

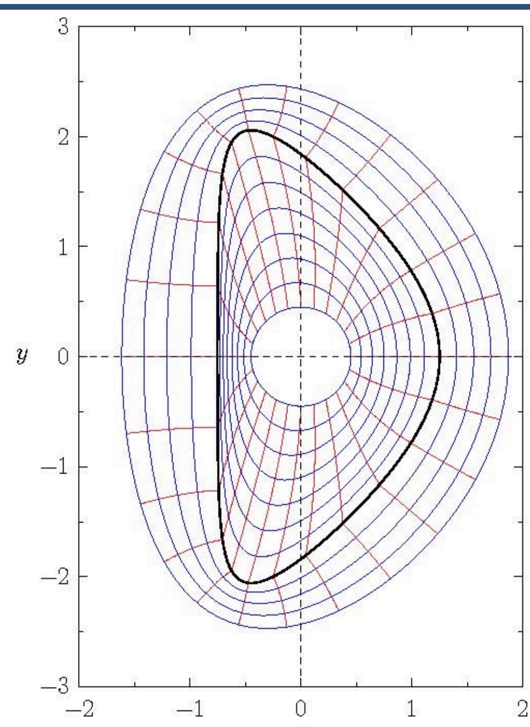

Fig. 1. Poloidal cross-section of a tokamak's magnetic flux surfaces (and corresponding orthogonal coordinate in red) produced by the plasma model described in the text. The heavy black curve indicates the plasma boundary where the current is concentrated.

Generally speaking, the response of a tokamak plasma to an error-field can be divided into ideal and non-ideal components. As the name suggests, the *ideal response* of the plasma is that predicted by linearized, marginally stable, ideal magnetohydrodynamics (MHD) (*i.e.,* $\boldsymbol{j} \times \boldsymbol{B} = \nabla p$, where $\boldsymbol{j}$ and p are the plasma current and pressure, respectively). This response consists of a combination of distributed currents, produced by the error-field induced distortion of the equilibrium magnetic flux-surfaces, and currents that are radially localized in the vicinity of the various rational surfaces inside the plasma. The latter currents are driven inductively by plasma rotation and oppose locked island formation.

As the name suggests, the *non-ideal response* of a tokamak plasma to an error-field cannot be described by ideal-MHD equations. The resonant component of this response is associated with *dissipation* (and residual magnetic reconnection) at the internal rational flux-surfaces, and it gives rise to a *locking torque* that reduces plasma toroidal rotation and thereby could trigger locked island formation.

As is well-known, a tokamak plasma that lies close to the ideal β-limit is able to substantially *amplify* an error-field, leading to a greatly enhanced locking torque [2]. Now, according to conventional ideal-MHD theory, the locking torque should peak when the plasma β reaches the *no-wall* β-limit (*i.e.,* the β-limit calculated in the absence of a conducting vacuum vessel). However, experimental observations indicate that the torque actually peaks when β attains a value lying somewhat *above* the no-wall β-limit [3]. It is generally supposed that this discrepancy between theory and observation is a consequence of the non-ideal component of the plasma response.

Recently, Institute for Fusion Science (IFS) scientists have shown that the calculation of the ideal response of a highly shaped tokamak plasma to an error-field can be greatly simplified by employing a large aspect-ratio magnetic equilibrium in which the pressure is uniform, and the current entirely concentrated at the boundary [4]. The resulting equilibrium is shown in Fig. 1. This approach allows the internal currents that constitute the ideal response to be replaced by equivalent surface currents. IFS scientists have also shown that the calculation of the non-ideal response of the plasma can be simplified by modeling each internal rational surface as a toroidally rotating, thin resistive shell that only responds to the appropriate resonant harmonic of the perturbed magnetic field. In a further simplification, it is assumed that the shells are all located at the plasma boundary. This approach, which essentially mimics continuum damping due to Alfven- and sound-wave resonances lying within the plasma, allows the internal currents that make up the non-ideal response to be replaced by equivalent surface currents.

Figure 2 shows the error-field amplification factor, calculated from the aforementioned IFS model, as a function of the normalized plasma β. The calculation is performed for the highly shaped plasma equilibrium pictured in Fig. 1. It can be seen that at relatively low non-ideal response levels, the amplification factor peaks strongly at the no-wall β-limit, in accordance with conventional ideal-MHD theory. However, at higher non-ideal response levels the peak amplification factor is reduced, but also shifts to the high-β side of the no-wall β-limit, in accordance with experimental observations [3].

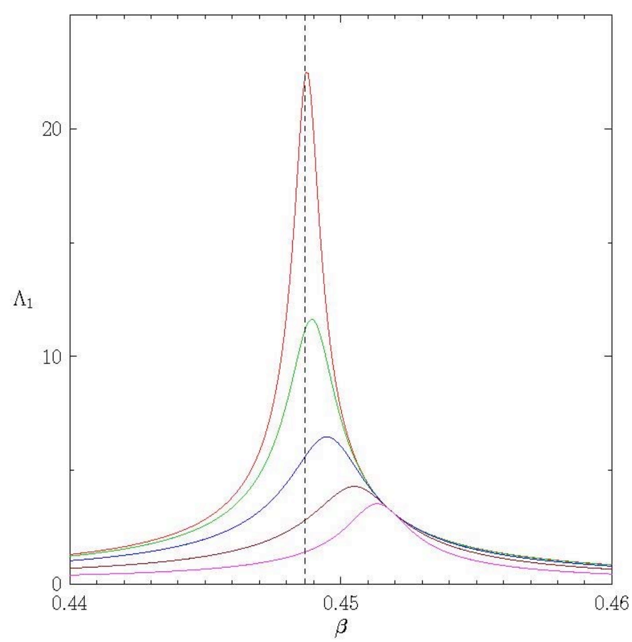

Fig. 2. The error-field amplification factor versus the normalized plasma-β for the magnetic equilibrium shown in Fig. 1. The no-wall (stabiiity) β-limit is indicated by the vertical dashed line. The red, green, blue, brown, and magenta curves indicate the effect of increasing levels of non-ideal plasma response.

References
[1] R. Fitzpatrick, Phys. Plasmas **5**, 3325 (1998).
[2] A.H. Boozer, Phys. Rev. Lett. **86**, 5059 (2001).
[3] H. Reimerdes *et al.*, Nucl. Fusion **49**, 115001 (2009).
[4] R. Fitzpatrick, Phys. Plasmas **15**, 092502 (2008).

Announcements

Submit BPO-related announcements for next month's eNews to Tom Rognlien.

Upcoming Burning Plasma Events

2010 Events

Oct 18-20
ITPA Energetic Particles Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-20
ITPA Transport and Confinement Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-21
ITPA Divertor and SOL Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-21
ITPA Integrated Operation Scenarios Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-21
ITPA MHD Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-20
ITPA Pedestal and Edge Physics Topical Group Meeting (in conjunction with IAEA FEC)
Seoul, Korea

Oct 18-22
ITPA Diagnostics Topical Group Meeting (in conjunction with IAEA FEC)
Naka, Japan

Oct 24-29
9th International Conference on Tritium Science and Technology
Nara, Japan

Nov 7-11
19th Topical Meeting on the Technology of Fusion Energy (TOFE 2010)
(embedded with 2010 ANS Winter Meeting)
Las Vegas, NV USA

Nov 8-12
52nd Annual Meeting of the APS Division of Plasma Physics
Chicago, IL USA

Nov 15-17, 2010
15th Workshop on MHD Stability and Control: "US-Japan Workshop on 3D Magnetic Field Effects in MHD Control"
Madison, WI USA

Nov 23-25, 2010 NEW
1st Joint ITER-IAEA TM on Analysis of ITER Materials and Technologies
Principality of Monaco

Dec 1-2, 2010
Fusion Power Associates Meeting
Washington, DC USA

Dec 6-10, 2010 NEW abstracts due Nov. 1, 2010
6th IAEA Technical Meeting on Steady State Operation of Magnetic Fusion Devices
Vienna, Austria

Dec 15
IEA-ITPA Joint Experiments Planning Meeting
Videoconference

2011 Events

April 6-9, 2011
ITPA Transport & Confinement Topical Group Meeting (following US/EU TIF)
San Diego, CA USA

May 2-4, 2011 NEW
2011 International Sherwood Fusion Theory Conference
Austin, TX USA

May 15-19, 2011
15th International Conference on Emerging Nuclear Energy Systems (ICENES)
San Francisco, CA USA

June 26-30, 2011
38th IEEE International Conference on Plasma Science (ICOPS) and the 24th Symposium on Fusion Engineering (SOFE)
Chicago, IL USA

Oct 16-21
15th International Conference on Fusion Reactor Materials (ICFRM-15)
Charleston, SC USA

Directories of Other Plasma Events

IEEE Directory of Plasma Conferences
Fusion Ignition Research Experiment (FIRE) Physics Meetings

Please contact the administrator with additions and corrections.